

# FusionLighting

DOCKET FILE COPY ORIGINAL

December 16, 1994

Mr. William F. Caton  
Acting Secretary  
Office of the Secretary  
Federal Communications Commission  
1919 M Street, N.W., Room 222  
Washington, D.C. 20554

RECEIVED

DEC 19 1994

FCC MAIL ROOM

Re: ET Docket No. 94-32

Dear Mr. Caton:

The FCC has proposed co-use of a portion of the ISM band, specifically 2.402 - 2.417 GHz., with fixed and mobile communication services. Fusion Lighting, Inc., strongly objects to this proposed sale.

Fusion Lighting, Inc., has invested several million dollars developing a new class of extremely efficient light sources, the electrodeless sulfur lamp. With the strong support of the United States Department of Energy, two projects were recently completed here in Washington, D.C., which showcase the potential of this technology. Fusion Lighting's electrodeless sulfur lamps now illuminate the east bay of the National Air and Space Museum and the main entrance of the Forrester building. Enclosed is further information on these two demonstration projects and the underlying sulfur lamp technology.

The electrodeless sulfur lamp represents a new class of light source with many fundamental advantages over all lamps that are now on the market. The sulfur lamp is very efficient, being seven to eight times as efficient as standard incandescent lamps and beating even the best of today's fluorescent and HID lamps. Unlike fluorescent or other energy efficient lamps, the sulfur lamp does not contain mercury or other environmentally suspect heavy metals. Being an electrodeless lamp, the sulfur lamp does not contain a filament or electrode, allowing extremely long bulb life. In addition, the spectra from the sulfur lamp matches that of sunlight, but without most of the damaging UV or IR rays. We believe that the sulfur lamp will play a significant role in a wide range of commercial, industrial, and potentially residential/consumer applications.

The response to the introduction of the sulfur lamp has been overwhelming and extremely positive. We have been swamped by hundreds of faxes and letters from potential users throughout the world seeking a better, more energy efficient light source. As an American developed product, it offers the potential to create a significant number of high paying jobs, improve the U.S. trade imbalance in terms of exporting these lighting products and decreasing

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List A B C D E

FUSION LIGHTING, INC.

301-251-0300 ☎

• 15700 Crabbs Branch Way, Rockville, Maryland 20855 USA

• FAX 301-279-0578

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Page Two

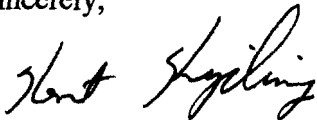
America's dependence on foreign energy. In the U.S., lighting consumes 17 percent of all electric power, over 34 quads of total energy.

One of the fundamental building blocks of the sulfur lamp is a microwave oven style magnetron. This device was chosen because of its commercial availability, low cost, and, most important, the frequency allocation established for industrial and scientific process activities.

We are concerned that the sale of a portion of the ISM band will adversely affect the future of electrodeless lighting. We believe that it would be very difficult for a reliable, new communication service to operate in the ISM band. This portion of the ISM band is already populated by over 200 million microwave ovens which emit "noise" in the band, thus making it difficult for any serious communication uses. Further development and growth of ISM equipment and applications would make the use of the proposed new communication service even more difficult than presently expected.

According to FCC Docket No. 94-32, "This spectrum would be made available for a variety of new services, creating new business opportunities and employment," within the communications service industry. Unfortunately, this may be at the expense of further development of equipment operating within this important ISM band. Specifically, we are very concerned that the proposed regulatory change will adversely affect the commercialization of advanced lighting systems. Fusion Lighting, Inc., would like the FCC to consider the economic and employment impact of such action which would result from the sale of the portion of the ISM band. In addition, the FCC should consider the reliability of any communication service in an ISM band where ISM equipment emits "noise" that could conflict with the use of such communication service.

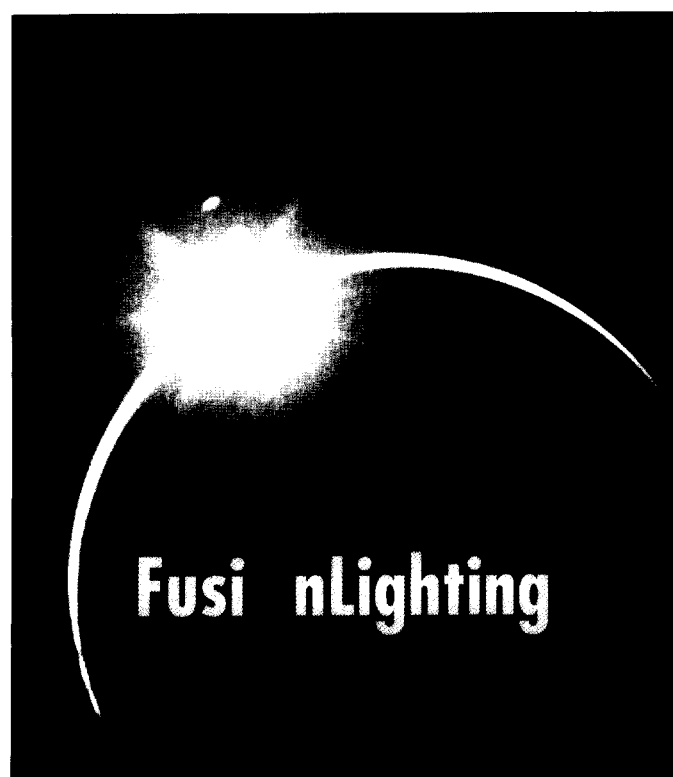
Sincerely,



Kent Kipling  
Vice President Operations

KK:cmc  
Enclosures

cc: M. Ury



# Energy Dept. Brings Dazzling Bulb to Light

By Curt Suplee

Washington Post Staff Writer

The Department of Energy yesterday unveiled what it called "a revolutionary 21st century" lighting system that uses a bulb of sulfur bombarded by microwaves to produce bright illumination resembling sunlight—and does so at a fraction of the cost of many conventional systems.

The prototype lamp, invented by a Rockville start-up company called Fusion Lighting Inc. and developed under contract to DOE, consists of a closed quartz sphere filled with an inert gas and a tiny amount of sulfur. One golf-ball-sized sulfur bulb, when irradiated by the kind of compact microwave generator found in ordinary kitchen ovens, puts out as much light as hundreds of high-intensity mercury vapor lamps.

The result is "a major technological breakthrough in lighting," said Christine Ervin, DOE's assistant secretary for energy efficiency.

Commercial products are not expected until sometime in 1995, and the first applications are likely to be in lighting extensive outdoor and indoor spaces such as shopping centers, aircraft hangars and factories. Illuminating such areas now costs the United States approximately \$8 billion per year, Ervin said. Use of the bulb in office or residential lighting is unlikely in the near future and would require much further research.

The first large-scale use of the lamp is being tested at the DOE's Forrestal



DEPARTMENT OF ENERGY

The sulfur lamp produces as much light as hundreds of high-intensity mercury vapor lamps—at a fraction of the cost.

Building headquarters in Washington. Two of the golf-ball-sized bulbs—one shining into each end of a 240-foot, 10-inch-in-diameter reflective plastic "light pipe"—have been installed in the building's entry area, which was previously lit by 240 175-watt mercury lamps. The new system, which uses less than 12,000 watts, produces four times as much light at approximately one-third the cost.

A similar test is being conducted at the

See LIGHT, A22, Col. 1

# Energy Dept. Is Aglow About New Bulb

LIGHT, From A1

National Air and Space Museum, where three 90-foot light pipes powered by sulfur bulbs have replaced 94 separate conventional fixtures in one display area. The test units put out three times more light at a 25 percent saving in cost, Ervin said.

Also important, said Frank A. Florentine, the museum's lighting director, is that the sulfur bulb emits much less ultraviolet light than traditional devices. UV radiation "is damaging to nearly everything" in the exhibits, he said—notably uniforms and space suits, some of which have already had to be replaced or renovated because they bleached or dried out under the existing lights.

Unlike most other high-intensity lighting sources, the sulfur lamp has no electrodes, which are the principal limitation to achieving long life in

conventional bulbs," Ervin said. And because there is no evidence that the sulfur reacts chemically to degrade the quartz, the lamp may not wear out for years. "We just don't know how long they'll last," said Fusion Lighting Vice President Kent Kipling.

The DOE expects initial lifetimes of 10,000 to 20,000 hours. That is comparable to the kind of high-intensity lamps commonly used for street lighting; but those frequently lose as much as half their light output by the end of their life spans. The developers expect the sulfur bulb to sustain nearly peak output throughout its life.

Others are less certain. "I'd be anxious to see independent test data," said Bob Davis, technology group leader at the Lighting Research Center of Rensselaer Polytechnic Institute in Troy, N.Y. "What will happen

over its lifetime? Will the color stay constant? Will it maintain its light output?"

Color is a major problem with many existing lamp designs. Sodium-vapor lamps are very energy-efficient, but their light is a harsh yellow. Mercury-vapor lamps put out blue-green illumination that makes red things look brown or black, although their bulbs can be coated with chemicals to improve the hue. (Metal halide lamps, currently used to light sports stadiums, industrial interiors and the like, produce nearly white light. But they have electrodes.)

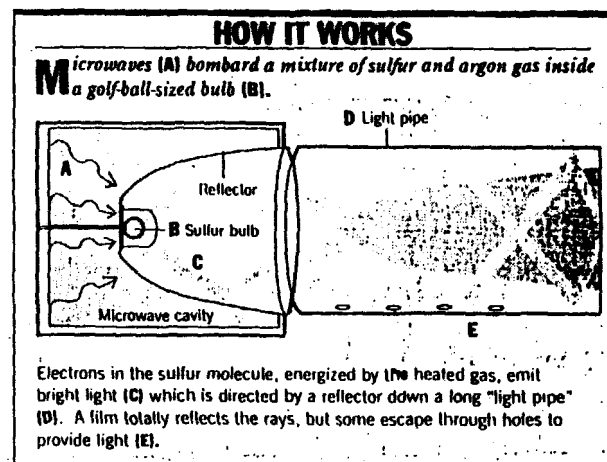
The electrodeless sulfur bulb, however, emits a white light that is optically very similar to sunlight. In initial agricultural tests, Kipling said, "plants behave as if they're seeing sunlight." NASA has a two-year contract with the company to develop lights for growing plants in space.

Lee Anderson, DOE's project manager for lighting research, said that the quality of light will be especially important to the increasingly detailed work done in U.S. high-tech factories.

Privately held Fusion Systems Corp. of Rockville, a publicly traded company that pioneered the use of microwave generators to produce ultraviolet light for applications such as making microchips or curing labels onto beer cans. Three years ago, researchers there substituted sulfur for mercury in a bulb and discovered that it generated a bright white light.

Anderson went to observe the experiment, got the department interested in a development plan and arranged for technical help from the Lawrence Berkeley Laboratory in California. Meanwhile, Fusion Lighting realized that the sulfur bulb's relatively low-temperature output would work well with the kind of light pipe invented by A.L. Whitehead of Vancouver and manufactured by JM.

"One of the missing links with that technology," said RPI's Davis, "has



BY JOHN ANDERSON—THE WASHINGTON POST

been a high-intensity source small enough to put in a reflector" that could be mounted on the end of the pipes. "The most exciting potential of

this lamp is in its use for distributed or remote lighting where the light source can be located at some distance away."

## BUSINESS TECHNOLOGY

# A Light to Replace Hundreds of Bulbs

A new type of energy-efficient, long-life lighting developed by a Maryland company with support from the Energy Department may allow the replacement of hundreds of floodlight bulbs with just a few of the new units.

The technology uses microwave energy to produce white light similar to that emitted by the sun. The microwaves excite the element sulfur, which is combined with an inert gas in a golf-ball-sized bulb. Unlike conventional light bulbs, there are no electrodes inside to burn out, the most common form of lamp failure.

The bulbs have been combined with plastic "light pipes" for testing at two installations in Washington, the Forrestal Building, which is headquarters for the Energy Department, and the Smithsonian Institution's Air and Space Museum.

In each installation, light from the sulfur bulb is projected by a reflector into long plastic pipes lined with a semireflective film. With either a mirror or a second bulb at the far end, the light reflects back and forth as it goes along the pipe, with some of it leaking through the semireflective film to illuminate the surrounding area.

At the Forrestal Building, a single light pipe 10 inches in diameter and 240 feet long, with a sulfur bulb at each end, has replaced 240 individual 175-watt high-intensity lamps to illuminate the entrance and the nearby roadway. Energy Department officials say the pipe gives off four times as much light as the series of bulbs it replaced, but consumes only one-third the electricity.

The Federal officials say that the sulfur in the bulb does not wear out and that the life of the units is limited only by the microwave generators, which last 10,000 to 15,000 hours. They said the cost of the light pipes for the two test installations was less than half the cost of the bulbs they replaced.

The sulfur lamp was developed by



The New York Times

The new lighting source at the Energy Department uses microwave energy to produce white light similar to that emitted by the sun.

Fusion Lighting of Rockville, Md. The light pipe was invented by A.L. Whitehead Ltd. of Vancouver, using plastic reflector films sold by Minne-

sota Mining and Manufacturing. Fusion Lighting expects to have a commercial product on the market next year. JOHN HOLUSHA

SCIENCE  
ENGINEERING

## A New Kind of Illumination That Burns Brightly, but Not Out

By Curt Supplee  
Washington Post Staff Writer

The Department of Energy is looking at the future in a whole new light.

Forget incandescent bulbs, fluorescent tubes and even metal halide lamps, says Lee Anderson, DOE's program manager for lighting research. Much of tomorrow's illumination, he and others believe, will come from electrodeless devices that have no parts to burn out—and that produce the kind of intensely white light suitable to the increasingly detailed work done in high-tech industry. "American workers need better lighting," Anderson said, "not only for attention to detail in microcircuits and small mechanisms, but in quality control."

## The Prototype

The brightest prospect of that kind is a revolutionary prototype bulb developed by Fusion Lighting of Rockville in conjunction with DOE: A tiny closed quartz sphere containing argon gas and a pinch of elemental sulfur. When zapped with ordinary kitchen-grade microwaves, the bulb gives off intensely bright and relatively cool rays that are remarkably similar to sunlight.

In unveiling test installations of the device last week at DOE headquarters and the National Air and Space Museum, Assistant Energy Secretary Christine Ervin called it "a major technological breakthrough."

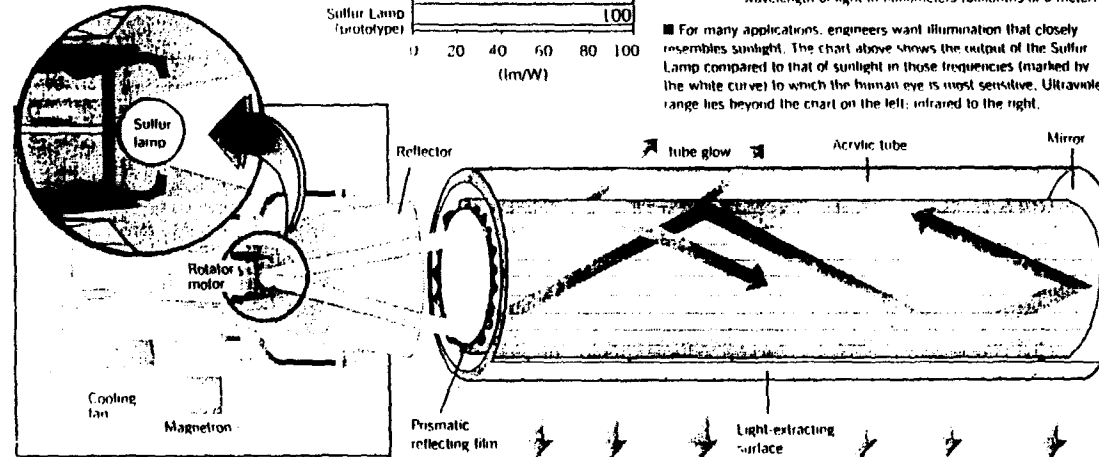
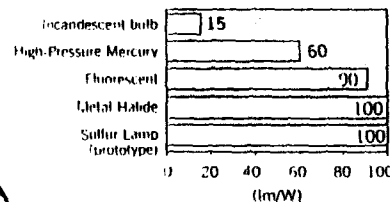
For all its novelty, however, the sulfur bulb still makes light the old-fashioned way: by temporarily altering the energy level of electrons in atoms. Electrons can occupy any of a number of different energy states while orbiting the atom's nucleus. Raising an electron to a higher level takes additional energy, just as moving a worker from her normal office on the second floor to temporary quarters on the fifth floor requires power from the elevator or the muscles.

Blasting an atom with extra energy from outside (heat in an incandescent lamp, solar particles in the northern lights, microwaves in the new sulfur bulb) will cause electrons to pop up to higher energy levels. This is an unnatural condition, and they soon drop back to their normal state. As they do, they shed their

Last week, the Department of Energy and a company called Fusion Lighting Inc. announced the development of a new device called the Sulfur Lamp. It produces bright white light by exposing a sealed quartz bulb containing argon gas and a small amount of sulfur to microwave radiation. In test installations at the DOE's Forrestal Building headquarters and the National Air and Space Museum, the bulb is coupled with 10-inch diameter "light pipes" that carry the rays over long distance.

## Comparing lamp efficiency

■ Different kinds of lamps can be compared by measuring the number of lumens (a standard unit of light flow) they emit per watt of energy use. Some approximate averages for various designs are listed at right.



SOURCE: DOE, Fusion Lighting Inc., McGraw-Hill Encyclopedia of Science &amp; Technology

excess energy in the form of photons: the individual units of light.

The color (wavelength) of the light depends on the kind of atom or molecule that is excited and the way its electrons are arranged. Sticking a bit of common salt—sodium chloride—in a flame, for example, will turn the flame yellow. Spraying the Earth's upper atmosphere with electrons and protons blown off the sun (which is what happens in the aurora borealis) will cause nitrogen to glow violet and blue, and oxygen to flash crimson or whitish-green. Running an electrical current through a tube of neon turns it bright red.

A wide variety of energy sources can be used to produce this phenomenon, including fire. When a candle is lit, the carbon and hydrogen atoms

in the wax are vaporized and combine in rapid combustion with oxygen in the air. The violent energy of the reaction excites electrons, which give off photons. A less messy way to achieve the same effect, Thomas Edison found, was to run a current through a wire filament and let the heat generated by electrical resistance turn the filament incandescent. In that case, the electrons of a tungsten wire are excited to the point at which they emit the familiar warm yellow-red illumination.

## No Need for Heat

But the source does not have to be incandescent, or even hot. In a fluorescent light, for example, small amounts of mercury are suspended

in a cold gas. As the current passes down the tube, it ionizes the gas, which in turn imparts energy to the mercury, whose electrons give off photons in the ultraviolet range. The UV rays then strike a special coating of phosphors on the inside of the tube. When excited by UV radiation, the phosphors (usually magnesium, zinc and cadmium compounds) shed their excess energy in the form of visible light.

Sodium-vapor or mercury-vapor outdoor lights work in a similar, though higher-intensity, fashion. In metal halide lamps—popular for lighting sports arenas and commercial interiors—an electric arc is run through a quartz tube containing a sophisticated mix of metals such as sodium, indium, thallium, scandium

or tin compounded with iodine. The combination of emissions from these metals produces a pleasing, near-white light.

## 'Noble Gases'

In each case, the elements of the lamp have to be kept in an oxygen-free environment so that they don't burn. The environment of choice has been one of the "noble gases"—helium, neon, argon, krypton or xenon—that are notoriously unreactive. A frequent choice is argon, a completely inert element that seeps from below the Earth's surface and makes up about 1 percent of air.

In the version of the Fusion Lighting lamp used to light a 240-foot-long area outside DOE's Forrestal

Building, a bulb about the size of a golf ball is filled with argon at one-tenth atmospheric pressure and approximately the amount of sulfur in a safety match. When the mix is irradiated with electromagnetic waves at 2.4 billion cycles per second (about what the average home microwave oven puts out), the argon heats up and vaporizes the sulfur, which forms into two-atom molecules.

As the molecules' excited electrons drop back to their ground states, the Fusion researchers found, they generate an unusually large quantity of photons in an uncommonly wide variety of types. The result is a spectrum, or range of wavelengths, very close to those in white sunlight, which is the combination of all colors generated by incandescence on the sun's surface.

The sulfur bulb gets so hot that it has to be rotated at 300 to 600 revolutions per minute to prevent the quartz from melting, which it would do "in about 2 seconds" if uncooled, says Fusion Lighting vice president Michael Ury. (Early prototypes also required two fans per bulb; later versions have eliminated that need.)

## Lacking Electrodes

One of the bulb's chief advantages is that it has no electrodes. Eventually, DOE's Anderson said, any electrode will break down or burn out, and multipart tubes often develop flaws in their glass-to-metal seals; consequently, the amount of light emitted declines over time. In general, Anderson believes, "electrodeless lighting is the thing of the future."

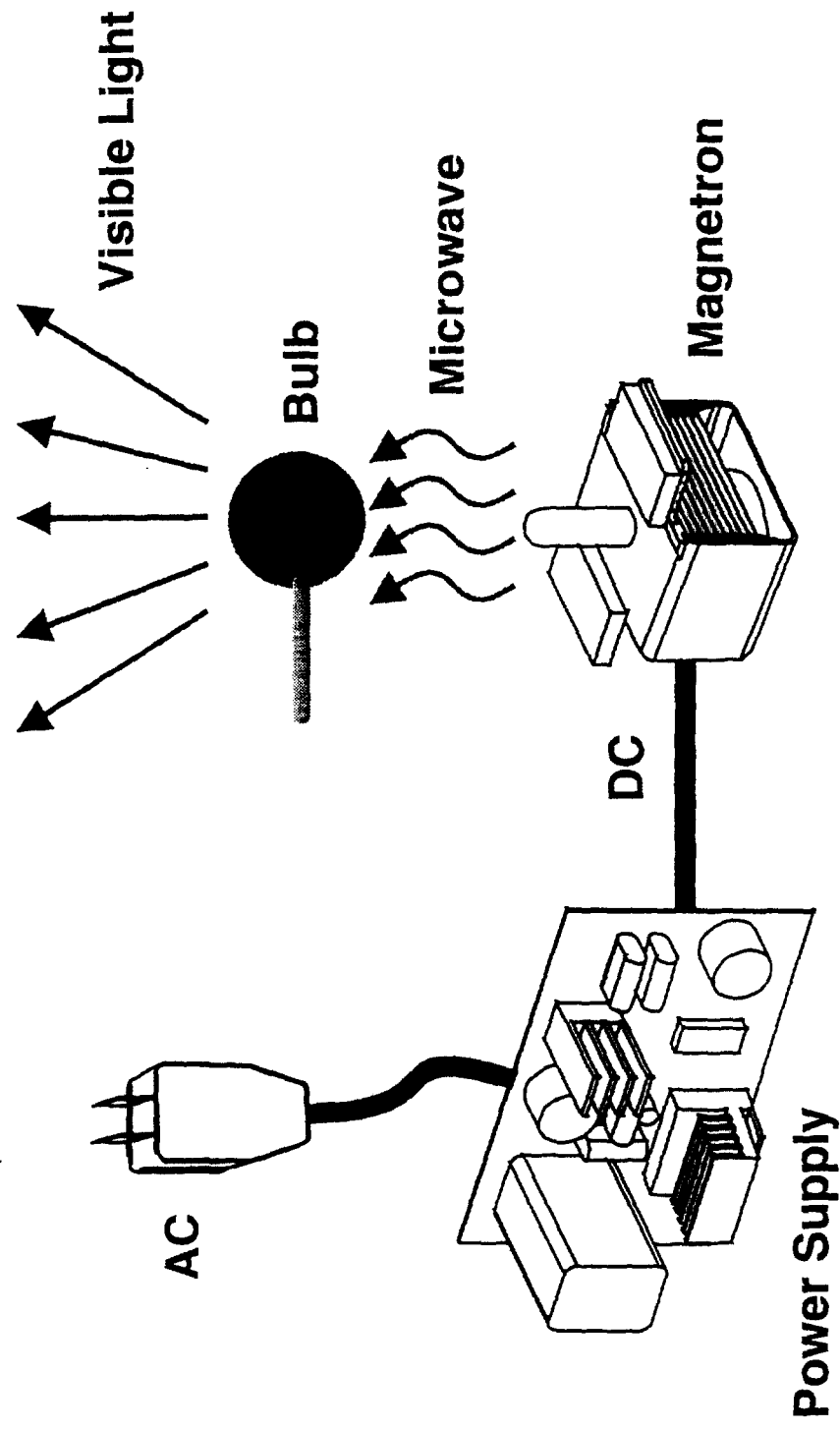
And in the case of the sulfur bulb, it is also, ironically, a thing of the past: Perhaps the first electric lamp—as constructed in 1850 by German physicist Otto von Guericke—was based on sulfur. As Michael Allaby writes in "Fire: The Vital Source of Energy": "When a globe filled with sulfur was rotated, fast and he held his hand against it, the sulfur glowed. He did not know it, but the friction of his hand was imparting an electric charge to the glass, which was exciting electrons in the sulfur atoms. In effect, he had discovered electric light."

**Fusion Lighting, Inc.**

\_\_\_\_\_ **FusionLighting**



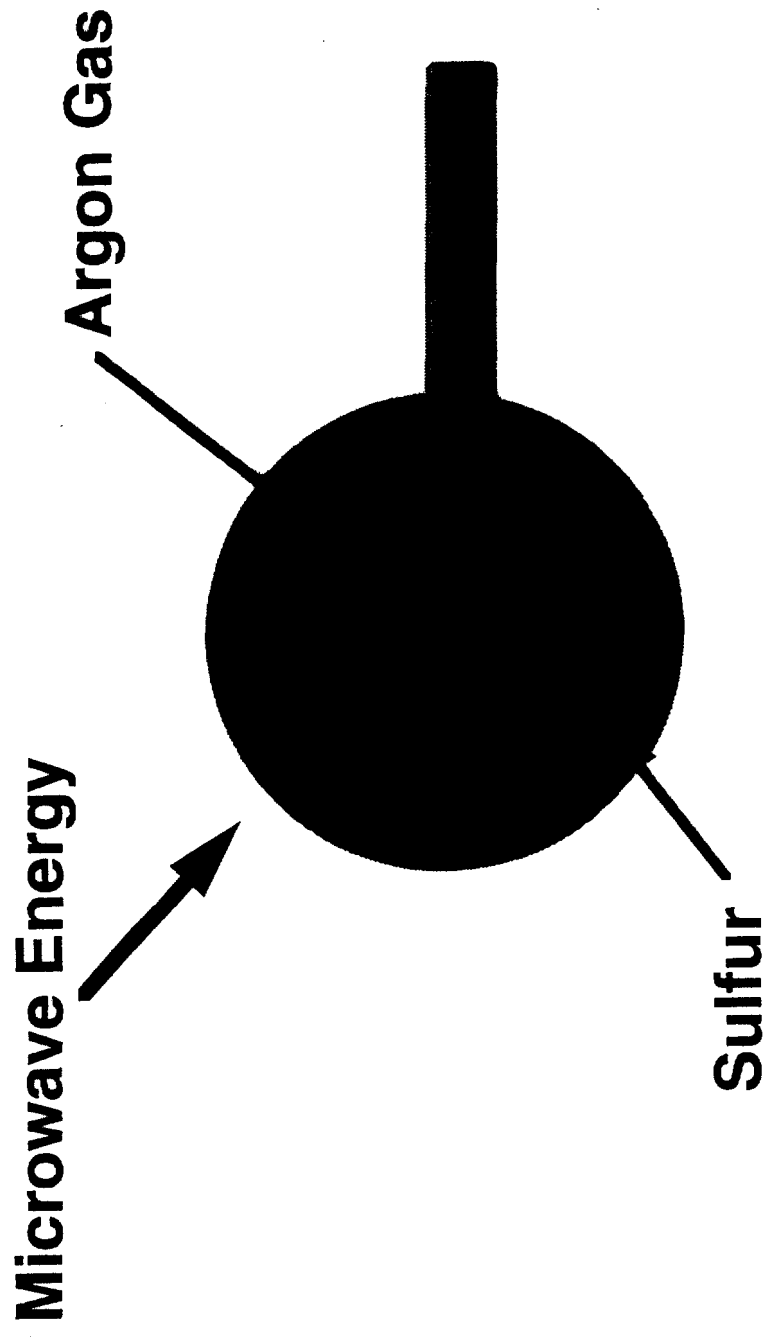
# Technology



**FusionLighting**

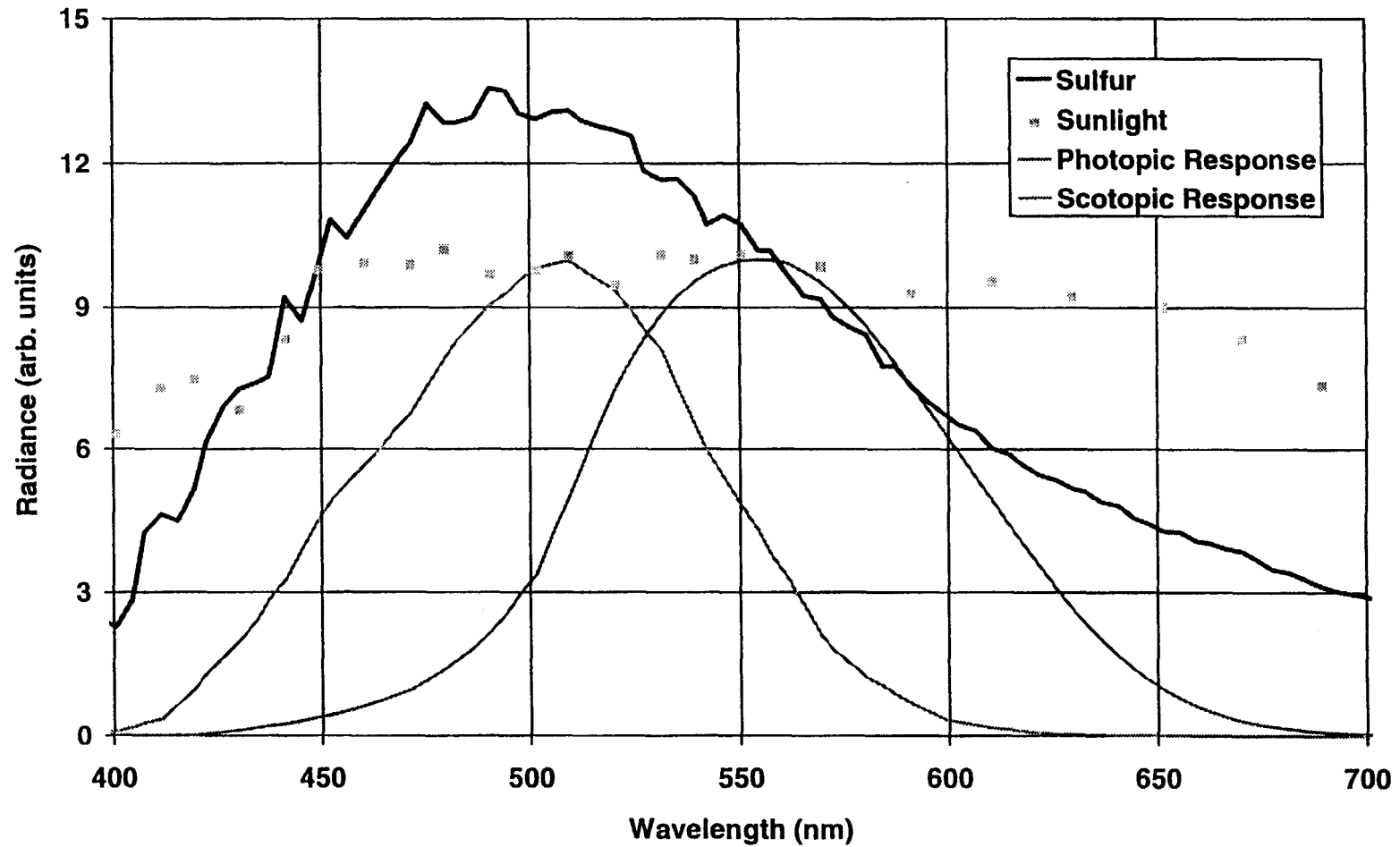
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# Microwave Electrodeless Lamp



\_\_\_\_\_ FusionLighting

# Spectra



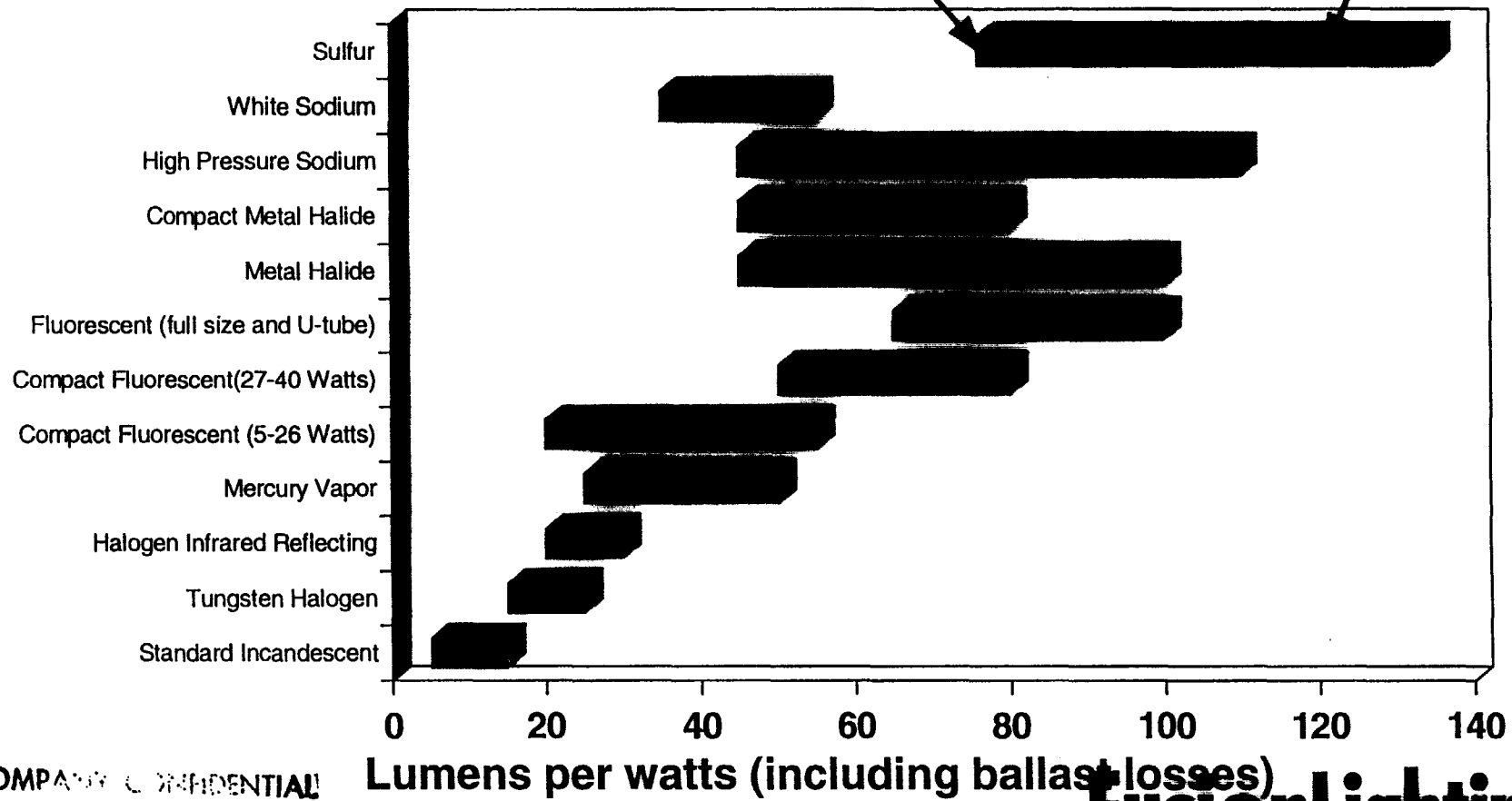
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**FusionLighting**

# Light Source Efficacies

Forrestal & NASM Demonstration

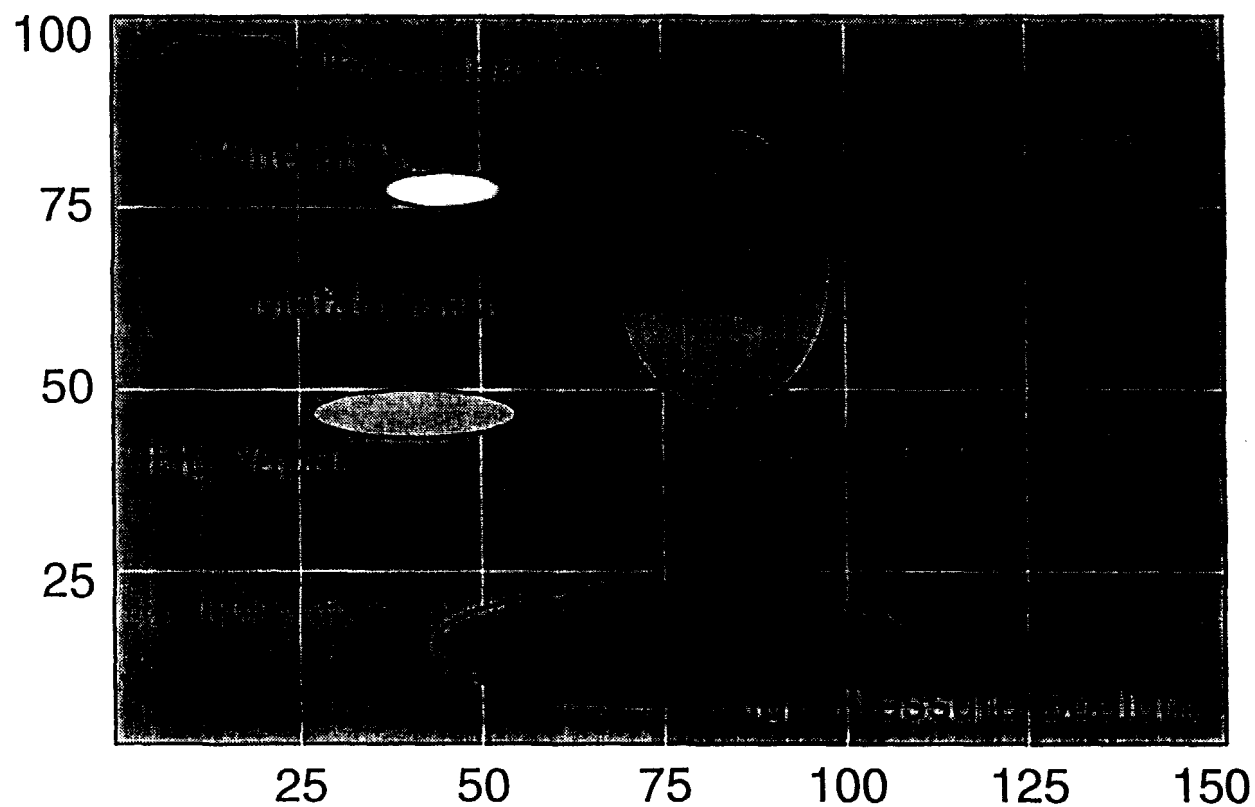
First Commercial Unit



COMPANY CONFIDENTIAL  
PROPRIETARY INFORMATION

**FusionLighting**

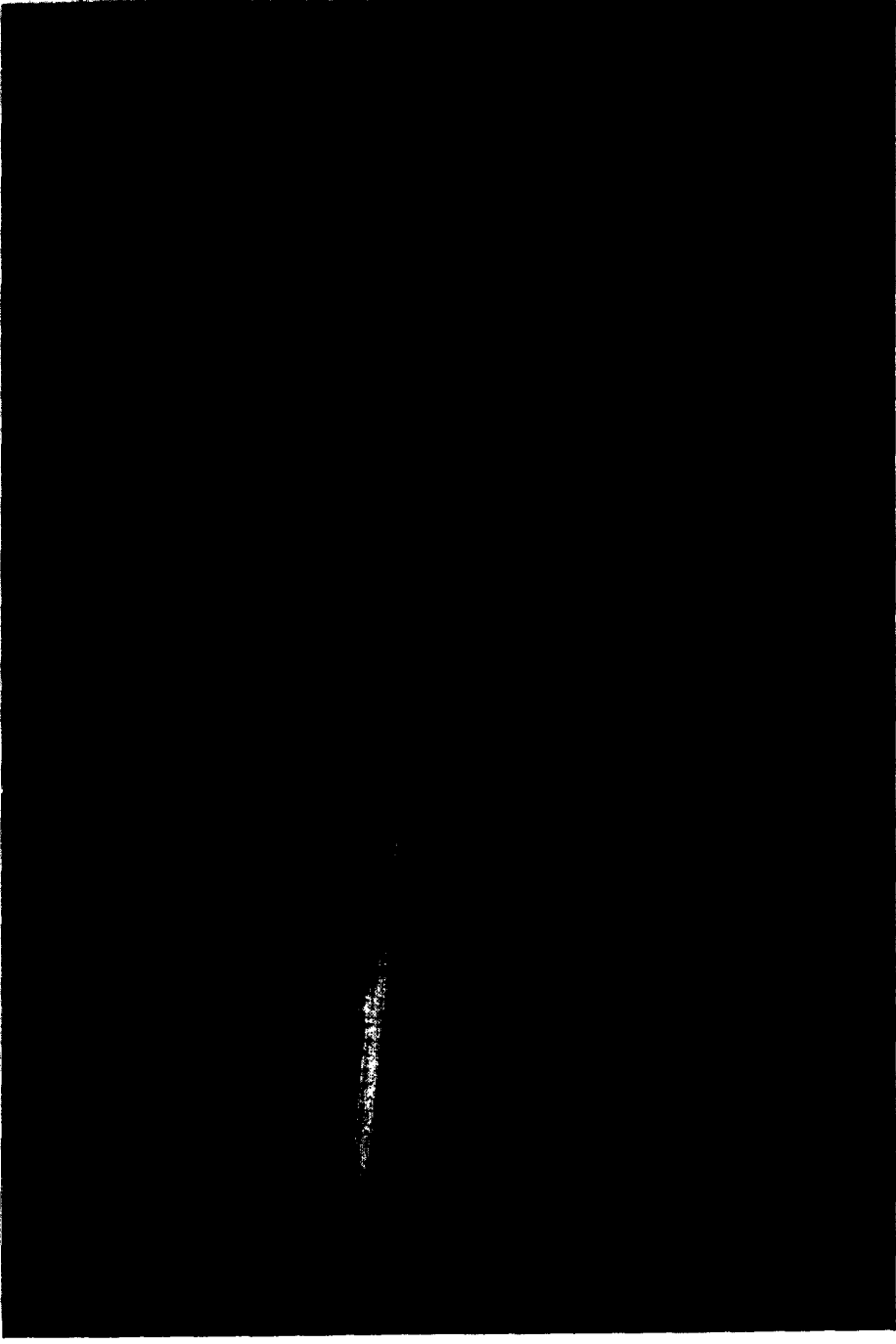
# Lamp System Efficacies



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PROPRIETARY INFORMATION

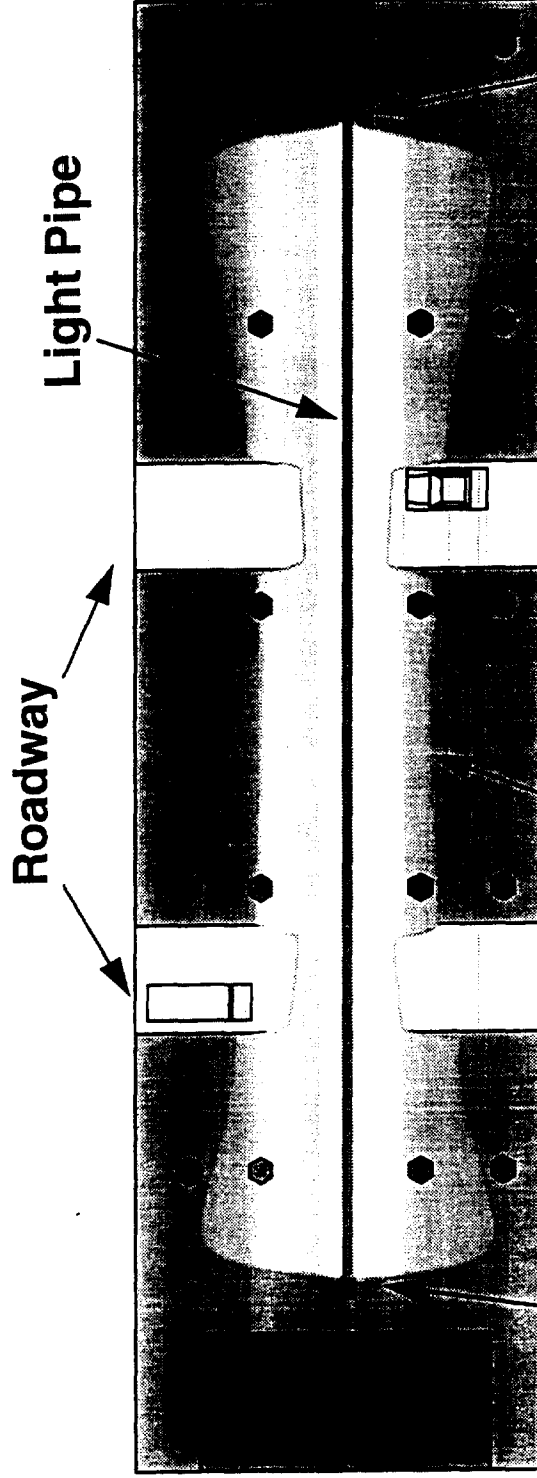
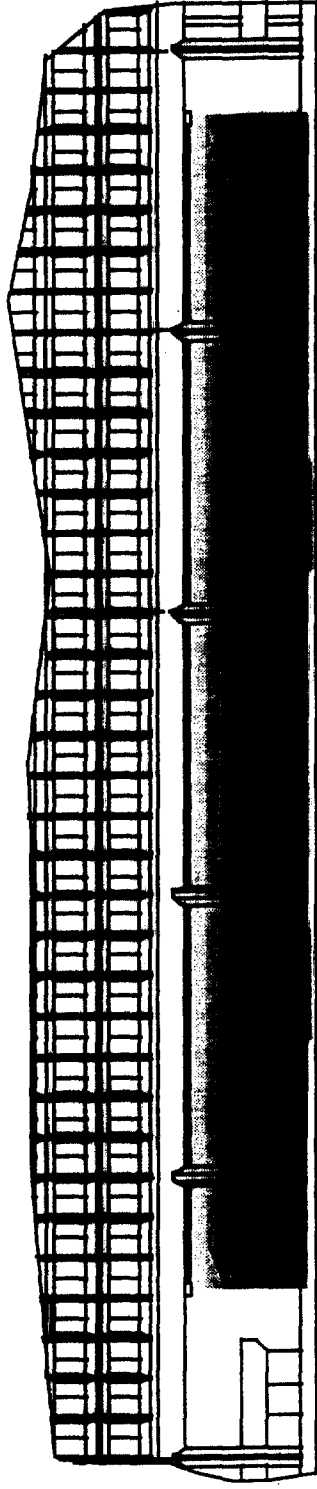
**FusionLighting**

**US Department of Energy  
Forrestal Building, Washington D.C.**



\_\_\_\_\_ **FusionLighting**

# Forrestal Building



Roadway

Light Pipe

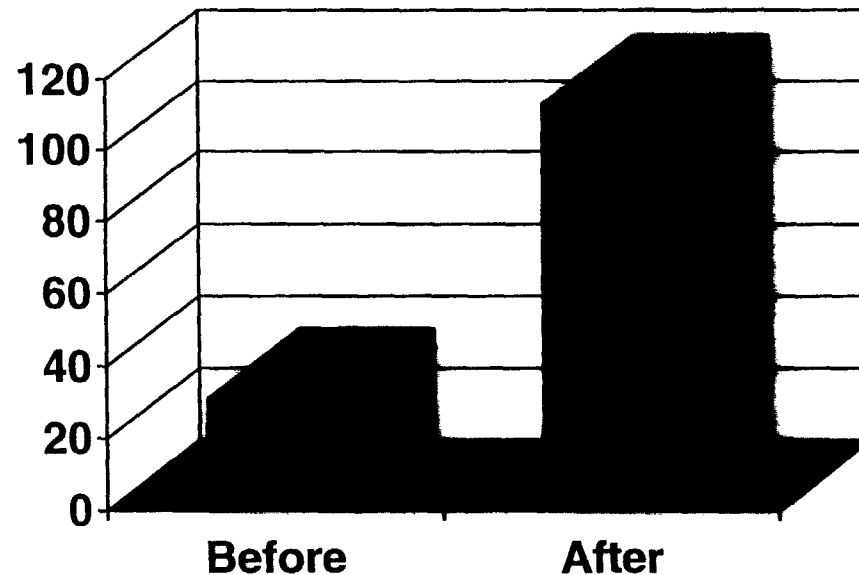
Sulfur Lamp

Light Output Intensity

Sulfur Lamp

**FusionLighting**

# U.S. Department of Energy Forrestal Building Light Intensity



The average light intensity values over space for the mercury lamps (Before) was 31 Lux compared with 113 Lux for the sulfur (After).

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**FusionLighting**



# U.S. Department of Energy Forrestal Building Energy Use

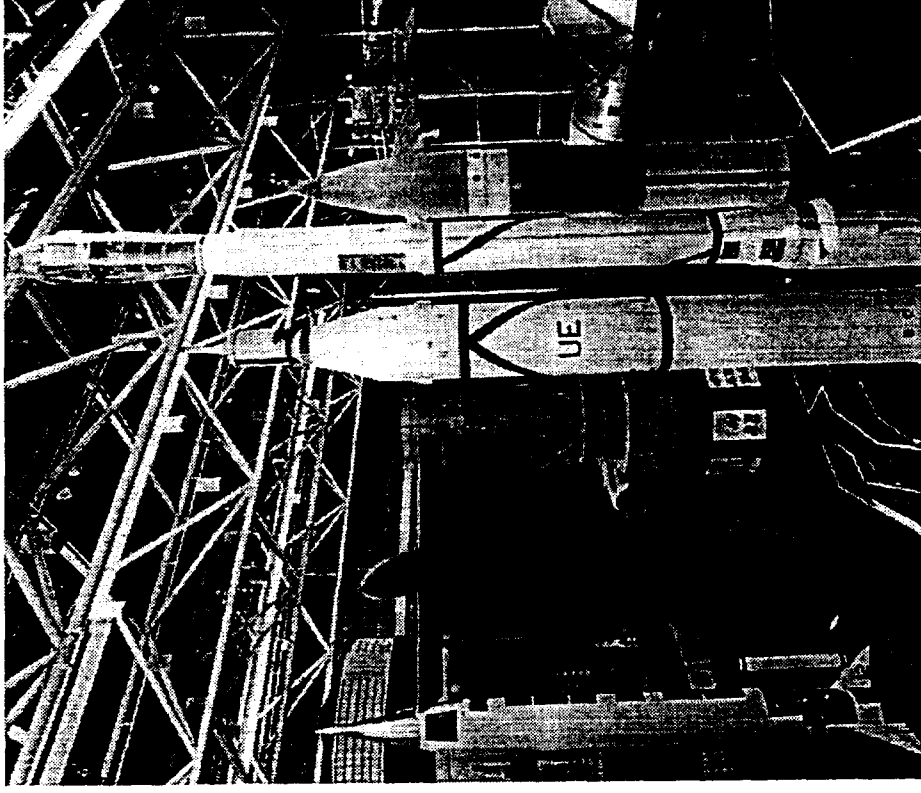


The total energy use for the mercury lamps (Before) was 42 K watts compared with 12 K watts for the sulfur (After).

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**FusionLighting**

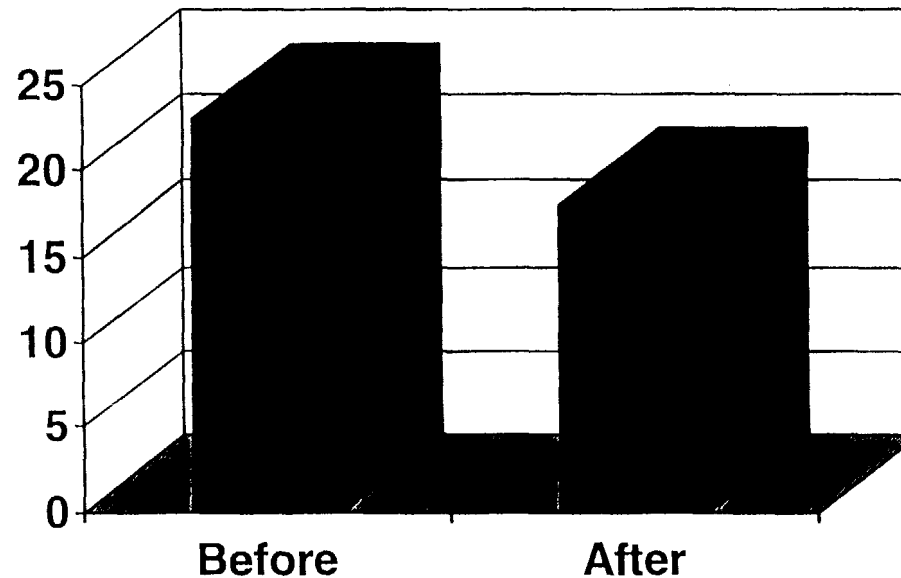
# National Air & Space Museum



**FusionLighting**

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# National Air & Space Museum Energy Use

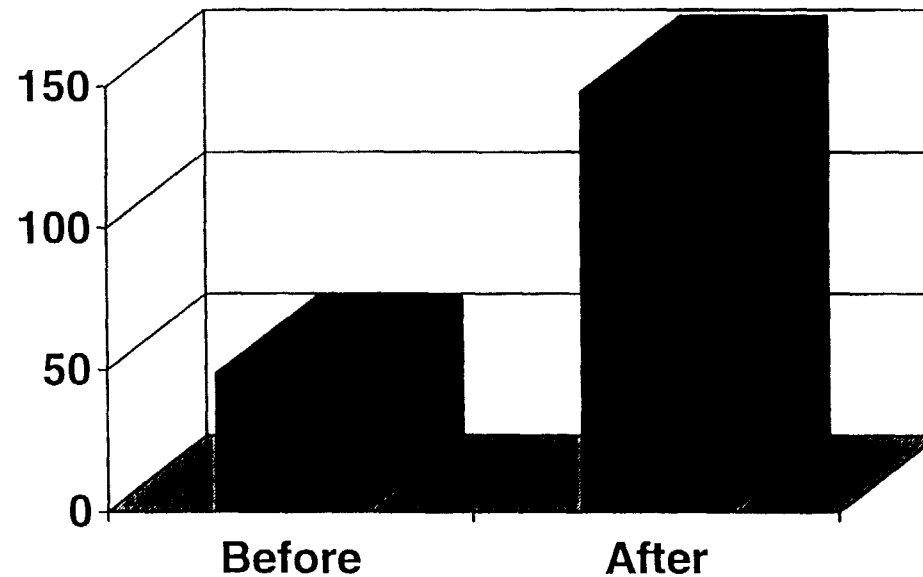


The total energy use for the mercury lamps (Before) was 23 K watts compared with 18 K watts for the sulfur (After).

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**FusionLighting**

# National Air & Space Museum Light Intensity

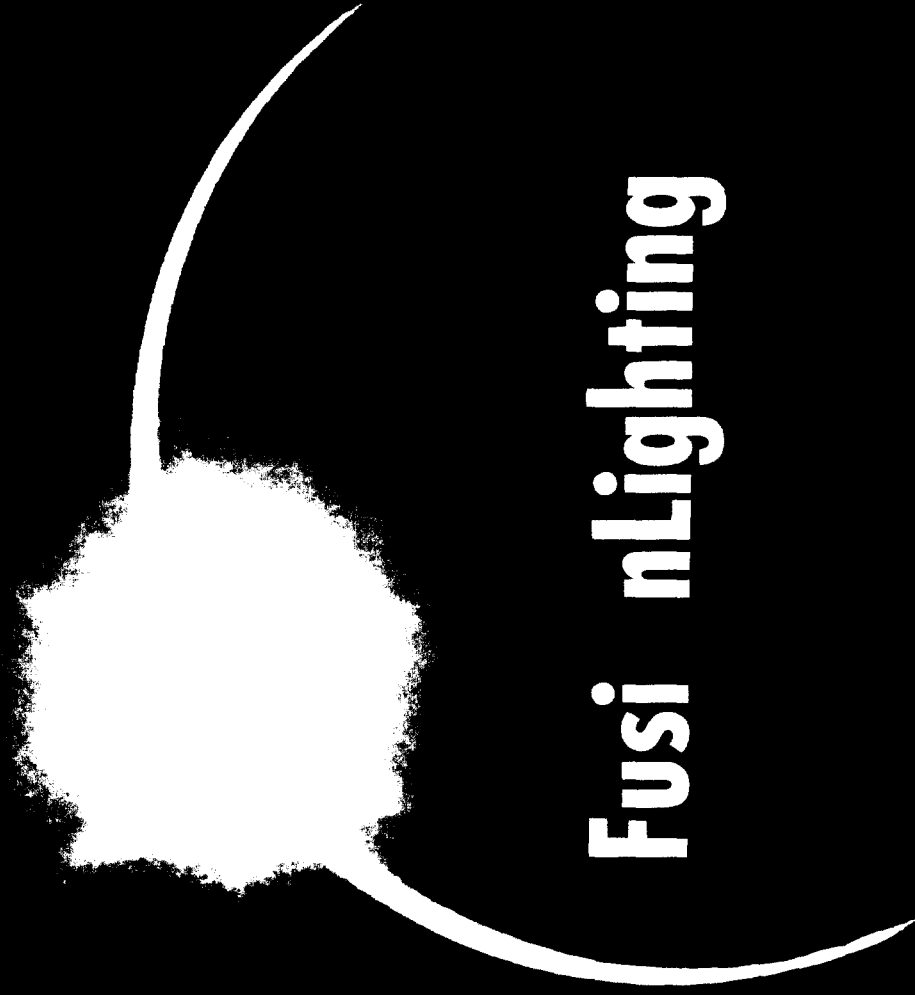


The average light intensity values over space for the mercury lamps (Before) was 49 Lux compared with 148 Lux for the sulfur (After).

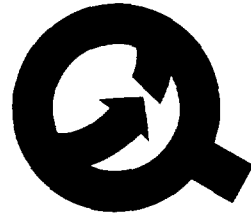
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**FusionLighting**

Redefining The Limits Of Light



**FusionLighting**



**FusionLighting**

Fax 301-926-7258

Call 301-251-0300

# A New Wave Of Innovation In Lighting

*B*righter, longer lasting and much more energy efficient are only some of the ways this new lighting system from Fusion Lighting has been described by those in the know. In its first application, two lamps, each the size of a golf ball, are being used to light the exterior of the Department of Energy's Forrestal Building in Washington, DC. The Smithsonian's National Air and Space Museum is using this new system to light the popular Space Hall. In the not too distant future, this new Fusion Lighting system will change the way you look at light through a whole array of applications from uses in street lighting, stadiums, factories and shopping malls, to helping crops grow with this replacement for sunlight.

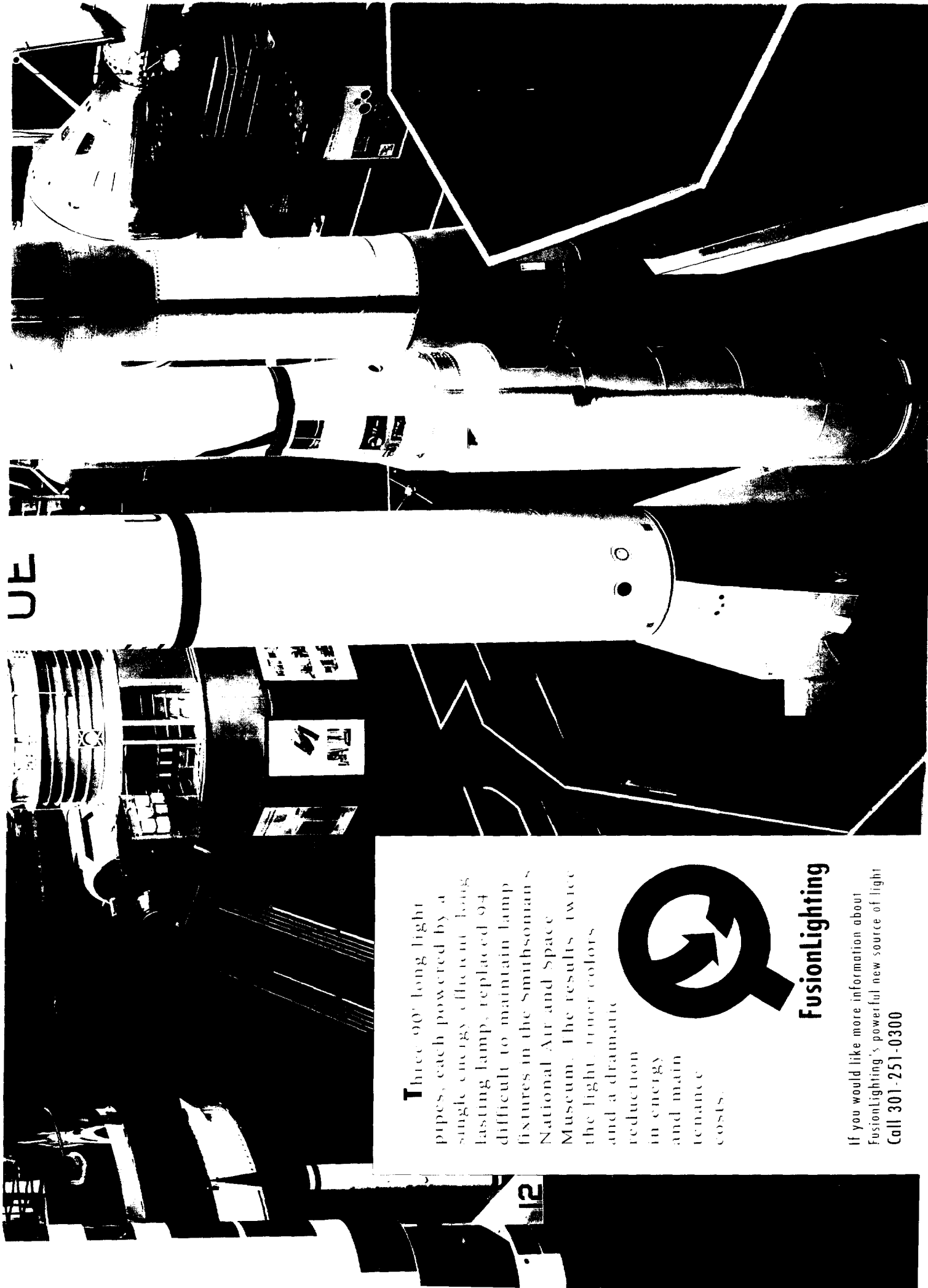


## FusionLighting

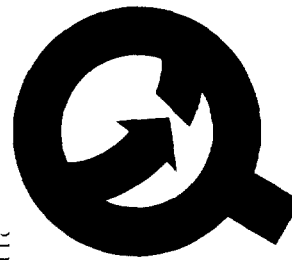


# A New Wave Of Innovation In Lighting





**T**hree 90' long light pipes, each powered by a single energy efficient, long lasting lamp, replaced 94 difficult to maintain lamp fixtures in the Smithsonian's National Air and Space Museum. The results: twice the light, truer colors and a dramatic reduction in energy and maintenance costs.



**FusionLighting**

If you would like more information about  
FusionLighting's powerful new source of light  
Call 301-251-0300



# NEWS

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# FusionLighting

Contact: Kent Kipling  
VP Fusion Lighting, Inc.  
(301) 251-0300

## **POWERFUL, NEW ENERGY-EFFICIENT LIGHT SOURCE TO LIGHT FORRESTAL BUILDING AND AIR AND SPACE MUSEUM**

**Washington, D.C., October 20, 1994:** Fusion Lighting, Inc. today announced the development of a new, highly-efficient light source. This new light source has been installed in the plaza of the Forrestal Building, the headquarters of the U.S. Department of Energy, and the large Space Hall of the Smithsonian's National Air and Space Museum, both on the Mall in Washington. Ceremonies to inaugurate the first use of the new system are scheduled to begin at the Forrestal Building in Washington, D.C. at 7pm, October 20. Immediately following, a similar lighting ceremony will be held at the Air and Space Museum. The announcement was made jointly by Christine Ervin, Assistant Secretary of the Department of Energy and by Les Levine, President of Fusion Lighting.

The new light source, designed and built by Fusion Lighting, represents a unique scientific breakthrough -- the use of sulfur gas excited by microwave energy to generate light. The result is an extremely bright and highly-efficient white light that closely matches the properties of sunlight. The lighting of the Forrestal Building and the Air and Space Museum are among the first practical uses of this new light source technology. In these two locations, a light pipe, designed and built by A.L. Whitehead Ltd. of Vancouver, Canada, collects focused light from a high-power sulfur lamp and distributes it evenly over large areas.

The sulfur lamp was invented three years ago by scientists and engineers now working at Fusion Lighting, a Rockville, Maryland high-technology firm. They discovered that sulfur, excited by microwave energy, could be used to produce a very bright, high-quality light.

According to Michael Ury, Vice President of Fusion Lighting and one of the inventors, "The benefits of this new light source are just beginning to be realized. To be sure, there is a great deal more work to be done and some problems need to be overcome, but the future is indeed bright. We are grateful for the confidence in our technology and for the cooperation we have received from the Department of Energy and from the Smithsonian Institute. We appreciate being allowed to install these new systems and to demonstrate, so publicly and so conclusively, the benefits of our lamps at their facilities. We hope this will encourage additional interest and support for additional applications both in the United States and abroad."

Additional information on the sulfur lamp and these two demonstration projects can be found on the fact sheet that accompanies this release or by contacting Kent Kipling at Fusion Lighting.